CSc 450/550
Computer Networks
Internet Backbone

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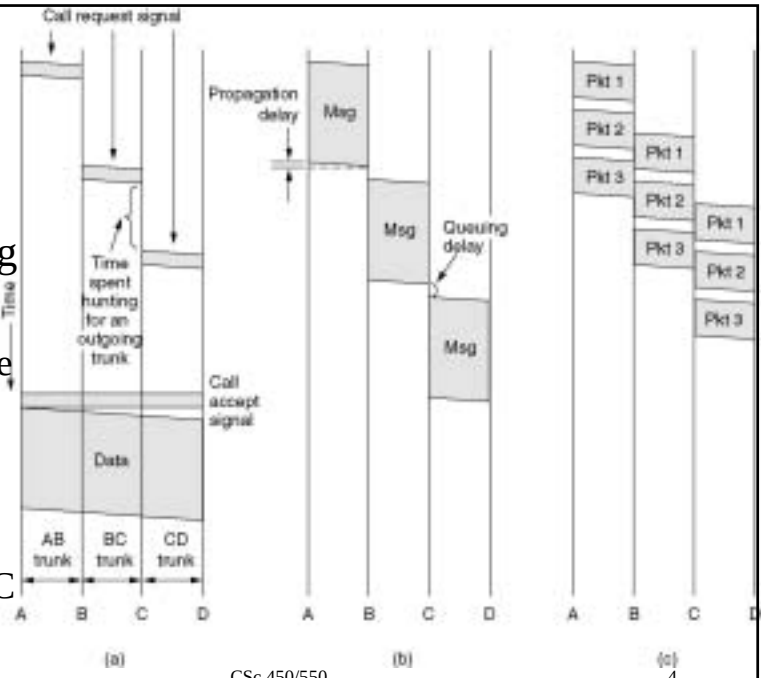
Review: Internet access

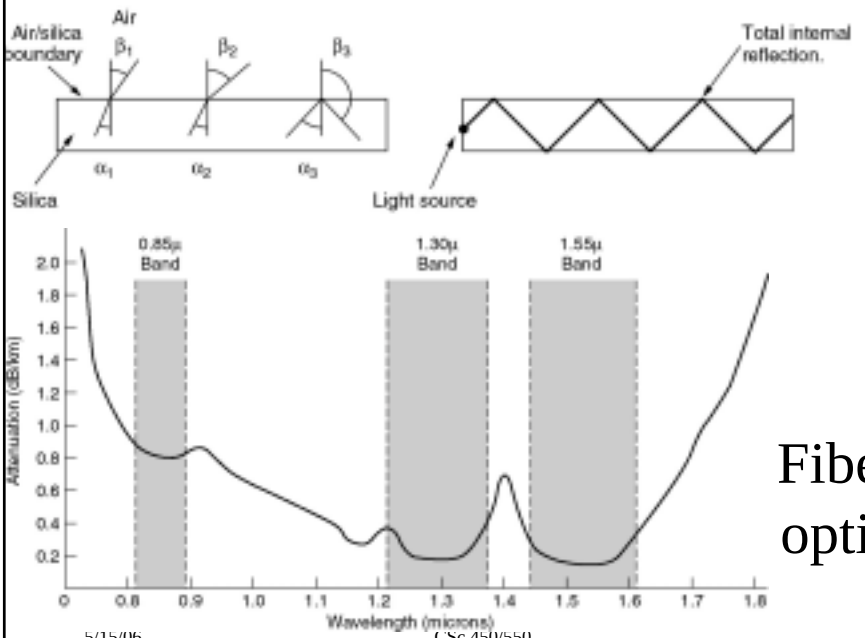
- Through phone line
  - dialup, DSL, modem
- Through cable line
  - cable modem
- Through local area network
  - Ethernet
- Over the air
  - wireless LAN, WMAN, cellular

Switching technologies

- Switched network
  - end-system, intermediate-systems*, end-system
    - intermediary: routing, resource utilization
- Circuit switching
  - phone - switches* - phone
    - resource allocated and dedicated at switches
- Packet switching
  - computer - routers* - computer
    - resource shared at routers



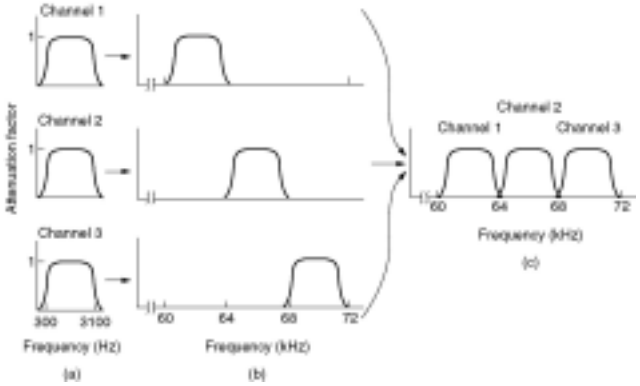
- Switching
  - circuit
  - message
  - packet
- Example
  - from A
  - thru B,C
  - to D
- Store-and-forward



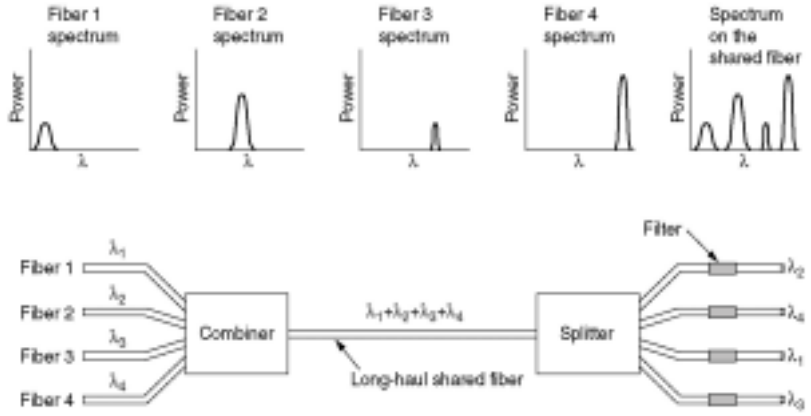
Fiber optic

Multiplexing technologies

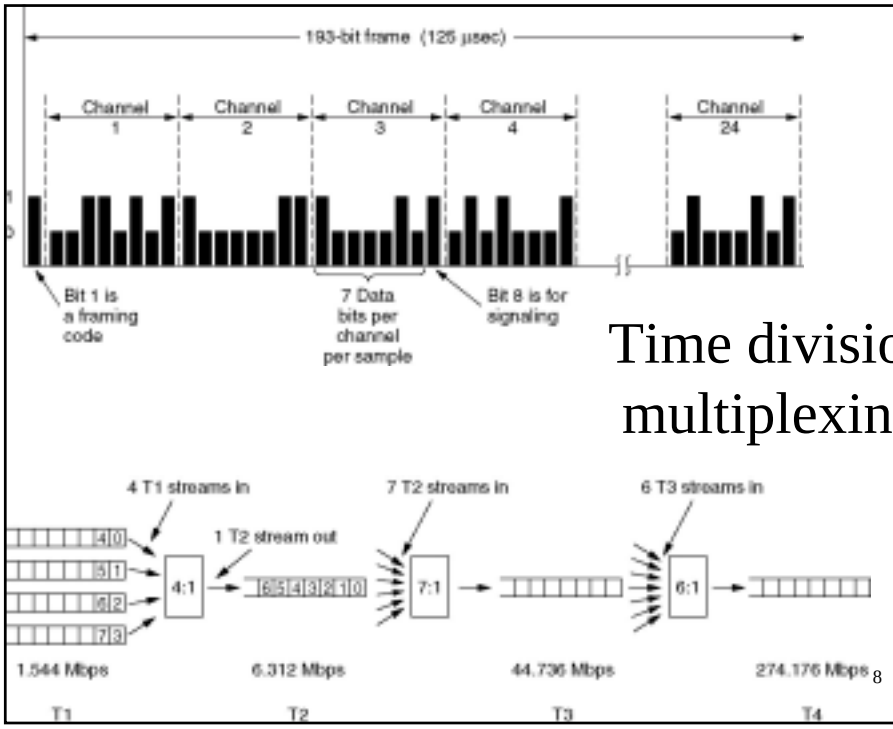
- Frequency division multiplexing (FDM)



Wavelength division multiplexing



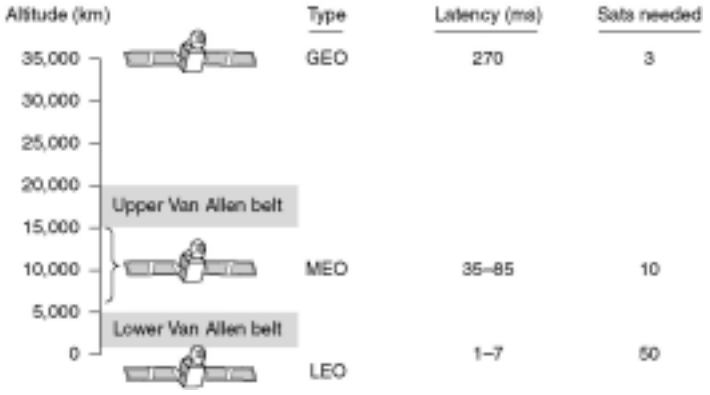
Time division multiplexing



SONET/SDH

SONET		SDH	Data rate (Mbps)		
Electrical	Optical	Optical	Gross	SPE	User
STS-1	OC-1		51.84	50.112	49.536
STS-3	OC-3	STM-1	155.52	150.336	148.608
STS-9	OC-9	STM-3	466.56	451.008	445.824
STS-12	OC-12	STM-4	622.08	601.344	594.432
STS-18	OC-18	STM-6	933.12	902.016	891.648
STS-24	OC-24	STM-8	1244.16	1202.688	1188.864
STS-36	OC-36	STM-12	1866.24	1804.032	1783.296
STS-48	OC-48	STM-16	2488.32	2405.376	2377.728
STS-192	OC-192	STM-64	9953.28	9621.504	9510.912

Communication satellite



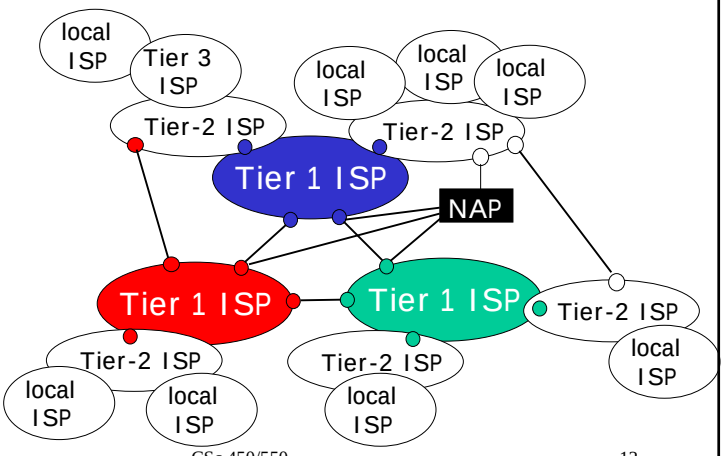
- Global satellite vs undersea fiber

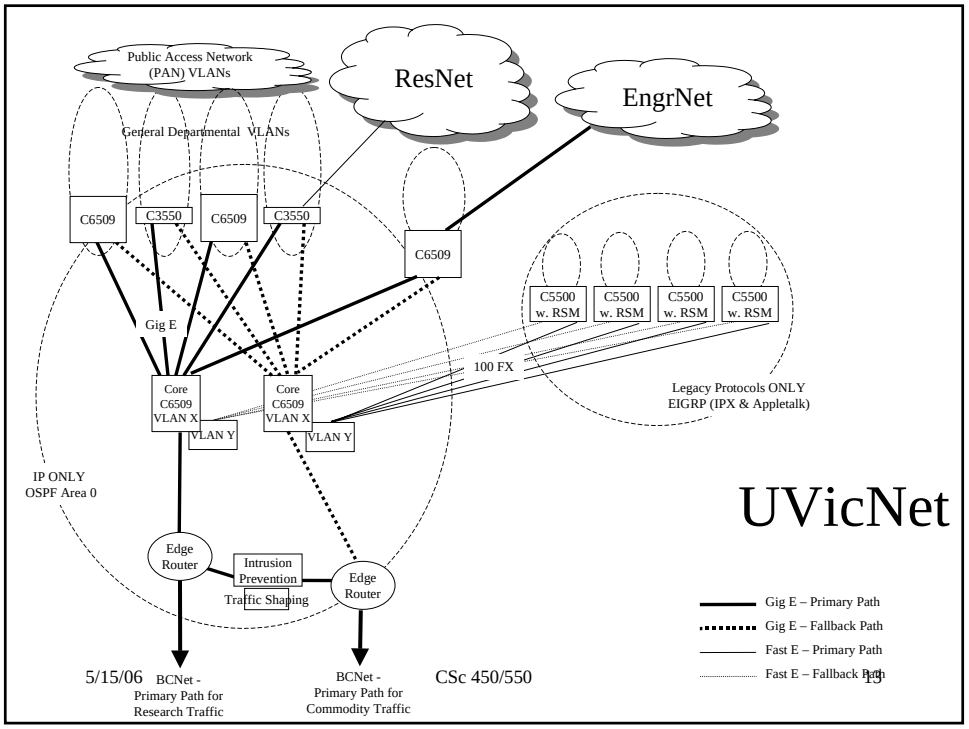
Internet backbone

- IP/ATM/SONET/WDM
  - IP: datagram
  - ATM: virtual circuit
  - SONET: circuit switching
  - WDM: lights in different color
- IP/SONET/WDM
- IP/WDM
  - newest technology

Backbone structures

- Tier-1
  - ATT
  - Sprint
  - MCI
- Tier-2
  - regional
- Tier-3
  - local





Link characteristics

- Speed (bandwidth): bit-per-second
- Delay: millisecond
  - transmission delay: packet length / link speed
  - propagation delay: travel distance / signal speed
  - processing delay
  - queuing delay: most complicated one
- Loss: percentage
  - transmission error
  - network congestion

This lecture

- Internet backbone technologies
  - circuit vs packet switching
  - multiplexing: frequency/wavelength, time
  - backbone structures: tiered ISPs
  - what appear to upper layers: bw, delay, loss, etc
- Explore further
  - link characteristics to google.com
    - /bin/ping; /usr/sbin/traceroute

Next lecture

- Applications layers
  - client-server model
  - HTTP
  - read CN Chapter 7.3